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THE OPEN-TANK METHOD FOR THE TREATMENT OF TIMBER.

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INTRODUCTION.

When the preservative treatment of timber was first introduced into this country, the lumber situation was wholly different from what it is now. There was a seemingly exhaustless supply of structural timber of the finest grades, and hence the preservative treatment of timber for different uses was economical only in the comparatively few cases where the cost of renewals was unusually high. As the supply of timber gradually diminished under the enormous inroads made upon our forest resources by the industrial development of the country, the prices of the better grades of timber doubled and trebled, until it is now difficult in many places to obtain regularly an adequate supply at any price. The increased cost of material has made it necessary to use less durable but more plentiful timbers, which require some form of artificial treatment before they can be expected to give as long service as the more durable woods. Hence the amount of timber subjected to artificial preservation has greatly increased, and the number and capacity of treating plants throughout the country have increased accordingly.

Most of the processes in general use require elaborate and expensive plants, consisting of closed retorts capable of withstanding high pressures, of vacuum and pressure pumps, steam boilers, etc. Such plants are usually stationary. The high cost of erecting them requires that they be located where the supply of timber will be continuous. This frequently means that timber must be transported long distances and double freight charges paid. Moreover, the interest on the investment and the cost of operating make it impracticable in most cases to use such plants for the treatment of timbers which are required in large quantities and at a comparatively low cost.

There has thus grown up a demand for some cheap and simple process of wood preservation adapted for timber in common use, for which the pressure methods are too expensive. The general adoption of such a process would largely increase the amount of timber artificially preserved, and so result in a great saving in the amount of timber consumed annually in the United States. It would insure the more complete utilization of the forest products, and encourage the use of many so-called "inferior," or quickly decaying, woods for purposes for which only high-grade, or decay-resistant, woods are now almost exclusively used.

HISTORY OF THE OPEN-TANK METHOD.

There have been many attempts to find a cheap and effective preservative process requiring no costly mechanical equipment. Most of these attempts were founded on an unsound theoretical basis, and many of them failed for other reasons. Obviously one of the simplest methods of securing a penetration is to boil the wood in the preservative, and this method has been frequently employed. It was not, however, until the year 1867, when Prof. Charles A. Seely, of New York, discovered and patented the process which bore his name, that the true value of the boiling method was ascertained. Through Seely's attempt to increase the penetration by immersing the timber in a bath of cold preservative after it had remained for some time in the boiling liquid was discovered the principle which later developed into the open-tank method of to-day. Apparently, however, Seely's investigations attracted but little attention at the time, and though some writers assert that his method was used in various parts of the United States, no record can be found to-day of its application on a commercial scale. It appears to have been practically abandoned after a few years.

At the Louisiana Purchase Exposition a series of experiments was undertaken by the Forest Service to determine some practical method of prolonging the life of fence posts. The expense of treating such timbers by the pressure processes was prohibitive; yet the receding of the forests, the agricultural development of the country, and the fencing in of large quantities of grazing lands in the West had depleted the supply of posts for farm purposes and raised their price. In the St. Louis experiments, boiling the posts in a vat containing tar oil was at first attempted, with only fair results, but in the course of the tests to increase the penetration the principle of the method once employed by Seely was revived. Subsequent developments in the experiments in which the Forest Service has applied this principle have resulted in what is now known as the open-tank method.

WHAT THE OPEN-TANK METHOD IS.

As already suggested, the open-tank method is based upon the use of an open tank, capable of withstanding heat, and either equipped with steam coils or so arranged that fire can be placed underneath.

Sufficient preservative is run into the tank to cover the portion of the timber which is to be treated, and the temperature of the liquid is then raised slightly above the boiling point of water. This temperature is maintained for a length of time depending upon the character of the wood and the treatment desired. At the end of the hot bath the timber is either quickly transferred to another vat, containing a cold preservative, in which it is submerged for a definite period of time, or else the heat is shut off and the timber is allowed to remain in the cooling liquid until the required absorption is obtained or until no further absorption takes place. The time required by the treatment may be shortened, without transferring the timber from one vat to another, by running out the hot liquid at the end of the hot bath and simultaneously letting in the cold liquid.

THEORY OF THE PROCESS.

The former theory of the process held that the hot preservative converted the moisture in the wood into steam and so expelled a large percentage of it, and that the cold bath condensed the steam in the pores of the wood and so formed a vacuum into which the preservative was forced by atmospheric pressure. In this way it was thought that the timber became seasoned just before or simultaneously with the entrance of the preservative. From this theory it also followed that green timber containing a large amount of moisture could be given a better treatment than seasoned timber, since the greater the amount of moisture in the wood the greater would be the vacuum formed when the vapor is driven off.

Recent experiments of the Forest Service with the open-tank process and with other processes have brought out, among other things, that though fairly good results were obtained by the open-tank method as formerly carried on, the theory itself was incorrect. The amount of space occupied by air in the timber was given too little consideration. It is true that a vacuum is created in the cellular structure of the timber, to destroy which the preservative is forced into the wood in part by atmospheric pressure. This vacuum, however, is principally produced not by the vaporization of the water, as was formerly supposed, but by the expansion and expulsion of the air within the wood cells and intercellular spaces. Wood, as is well known, is a very poor conductor of heat. It is almost impossible, therefore, in any reasonable time to heat a piece of timber to or above the boiling point of water, except in a thin exterior layer, without employing temperatures which would injure the fiber and volatilize large quantities of the preservative. Hence it is unreasonable to suppose that any considerable quantity of the water in the interior of the wood is sufficiently heated by the open-tank method to volatilize and escape.

If, again, as was formerly held, the creation of the vacuum were due wholly to the volatilization of the moisture in the wood structure, it naturally would follow that green wood, which contains relatively large quantities of water, would secure a stronger vacuum and therefore a better penetration than would seasoned wood from which most of the moisture had already evaporated. But numerous experiments carried on by the Forest Service have conclusively shown that, no matter what the process of treatment, a deeper and more uniform penetration will be secured if the timber is first seasoned, so that any theory which appears to explain why green timber is better adapted to treatment than is seasoned timber must be founded partly on error.

For the foregoing reasons, whatever quantity of water is driven off in the treatment of green timber must come chiefly from the outer layers. This quantity is of relatively little importance when the whole amount of water contained in green timber is considered. The importance of the expelled air is shown by the numerous bubbles that appear on the surface of the hot liquid during the treatment of seasoned timber, in which the cell openings and intercellular spaces are largely filled with air instead of water.

It is a familiar law of physics that at the boiling point of water it expands much more than air does, whereas at lower temperatures the reverse is true. Since, in practice, the wood can not be heated throughout by the open-tank method to the temperature of boiling water, the lower temperatures which are actually maintained must naturally have a greater effect on the air within the cellular structure than on the water.

Finally, according to the former theory the exposure of the timber to the air for more than a few seconds during the transfer from the hot to the cold bath would be sufficient to lower its temperature below the condensing point of steam, and this cooling would produce at least a partial vacuum, which would be destroyed by the entrance of air. As a matter of fact, however, a very good penetration can be secured after the timber has been exposed to the air for several minutes, especially in the case of seasoned timber of a porous nature. In other words, the temperature of the timber may fall to a point considerably below the condensing point of steam and still retain air expanded to such a degree that it will still further contract when immersed in the cold fluid and thus produce a vacuum which will be destroyed only by the forcing of the fluid into the cellular and intercellular spaces by atmospheric pressure.

In consideration of these and other observations it is believed that the creation of the vacuum is due in a larger degree to the expansion and driving off of the air than to the vaporization and driving off of the moisture; that while the latter assists in producing the vacuum it is not so important as was formerly held, and a good vacuum can be secured without it.

Capillary attraction undoubtedly assists in the penetration of the preservative, though it is of secondary importance, especially where the absorption is at right angles to the grain of the wood. It is obviously greater in seasoned wood than where the intercellular spaces are obstructed by sap.

METHODS EMPLOYED.

AMOUNT OF ABSORPTION AND DEPTH OF PENETRATION.

In the treatment of any timber by any process, the added life is directly proportional to the amount of absorption and the depth of the penetration secured. But where an expensive preservative is used, or where only a limited service is desired, it is often necessary to limit the absorption of the preservative and so, in a measure, lessen the penetration. It was in the effort to determine some method by which the amount of absorption and penetration of the preservative could be controlled with a fair degree of accuracy that the true respective values of hot and cold baths were demonstrated.

It is now established that the hot bath should be continued long enough to heat the timber and expand the air through a deeper zone than it is desired to penetrate with the preservative; and that the depth of the penetration should be regulated by the cold bath rather than by prolonging or shortening the hot bath and allowing the timbers to remain in the cold preservative for an indefinite time. A thorough heating gives a much better and more even penetration, by expanding the openings into the cellular spaces and allowing freer circulation through the pores of the timber. Moreover, when the outer zone has been thoroughly heated the timber may be removed from the cold preservative before the vacuum has been completely destroyed in the interior of the wood, and in this way a better penetration is secured with a less amount of the preservative, since the liquid in the outer saturated zone is drawn in after the timber is removed, leaving the surface clean and dry. It has frequently been shown that very little penetration is obtained in the hot bath, and that almost the entire penetration is secured during the cold or cooling bath. This holds in all cases unless the timber is thoroughly seasoned and absorbs the preservative with exceptional readiness.

TEMPERATURE.

The temperature used in the open-tank treatment must depend on the nature of the preservative and the condition of the timber. If water solutions are employed, the hot bath should be carefully kept at the boiling point. If the temperature is allowed to fall intermittently during the treatment, the vacuum in the timber will be partially destroyed by the entrance of the preservative, which will obstruct the escape of the air when the temperature again rises. With complex and expensive preservatives, such as creosote oil, the temperature should be kept as low as is consistent with securing the desired penetration, since the loss by volatilization during the treatment is almost directly proportional to the temperature and duration of the hot bath. For this reason the tank should be so constructed that a minimum amount of oil surface is exposed to the air.

In treatment by the pressure-cylinder processes, especially if the timber has already reached a more or less air-dry condition, care must be exercised to prevent the temperature from rising to a point injurious to the wood fiber. With the open-tank method, however, at least with the preservatives in use at the present time, there is much less likelihood of injury from this source. In the case of salt solutions, the boiling points do not greatly exceed that of water; in the case of oils, their volatility, even at temperatures far below the boiling points of any of their constituents, renders it necessary to keep the temperature at the lowest practicable point if the most economic treatment is to be secured. The treatment of green timbers and timbers which do not absorb the preservative readily requires the use of higher temperature through longer periods.

In selecting creosote oil for all open-tank treatments, in order that the loss by volatilization may be reduced to a minimum, the preference should be given to oils which contain the largest percentages of constituents with high boiling points. This is especially true if the character of the timber calls for an unusually severe treatment. In general it may be said that for green timber the temperature should not exceed 230° F. nor fall below the boiling point of water. For seasoned timber the temperature should not be allowed to exceed the boiling point of water by more than 8 or 10 degrees.

DURATION OF TREATMENT.

It has already been shown that the duration of the cold bath depends upon the penetration which it is desired to secure. Porous timbers of small dimensions may be saturated after a comparatively short immersion in the cold bath, while for larger sizes, and for timbers which do not absorb the preservative readily, several hours are necessary. The duration of the hot bath will depend upon the size of the timber, its moisture content, and the ease with which it absorbs the preservative. In general, however, it may be said that the maximum penetration for green timber can be secured by a hot bath of from eight to ten hours followed by a cold bath of from eight to sixteen hours; whereas seasoned timber will require only from three to six hours in the hot preservative, followed by a sufficiently long immersion in the cold bath to secure the desired penetration, probably in no case exceeding eight hours.

When the timbers are transferred from hot to cold oil they should be exposed to the air no longer than is absolutely necessary. In treating small timbers, which are easily and quickly handled, it is better to change the timbers from hot to cold oil than to permit the oil to cool or to change the oil in the treating tank.

APPLICATION AND LIMITATIONS OF THE OPEN-TANK METHOD.

Any of the preservatives in general use can be applied by the open-tank method, provided that the temperatures are properly controlled. Oils with high boiling points are applied with less difficulty and less loss by evaporation than those with low boiling points. In applying preservatives held in water solution some of the water is evaporated during the treatment, with a consequent strengthening of the solu-

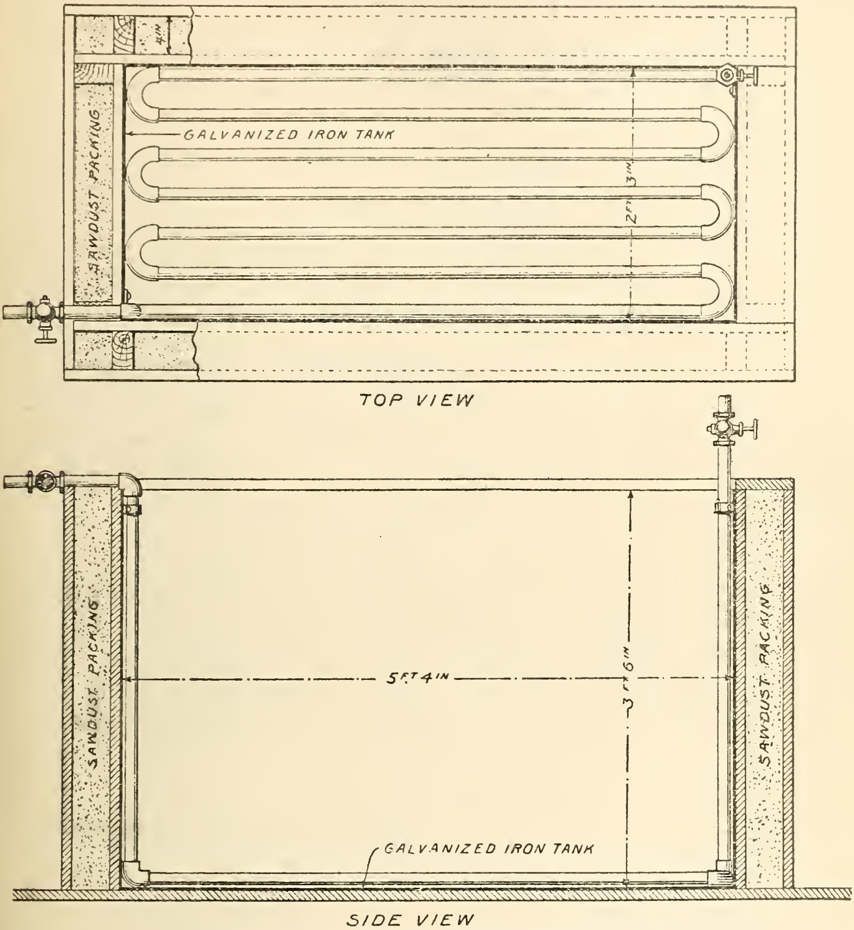

FIG. 1.—Diagram of an experimental tank used for treating fence posts.

tion; but treatment can easily be regulated either by the addition of hot water during treatment, or, better, by using a solution slightly weaker than desired for impregnation.

The open-tank method is applicable to the treatment of fence posts, telephone poles, mine props, small dimension timbers, cross-ties, piling, and similar timbers. Figures 1, 2, and 3 are diagrams of experimental tanks used for the treatment of fence posts, telephone poles, and mine timbers. Figure 4 is a diagram of a small commer-

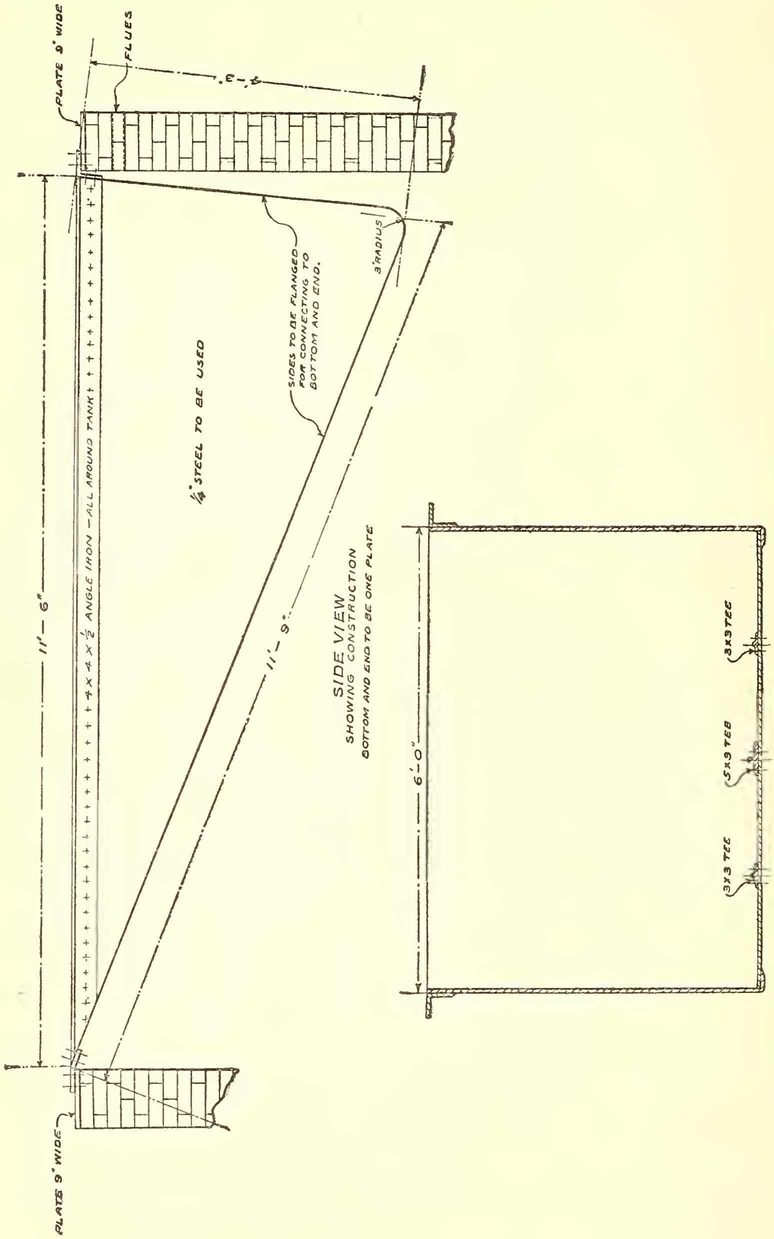

Fig. 2.—Experimental tank used for treating telephone poles. (Lower diagram shows strengthening tees on bottom of tank.)

cial plant for the treatment of mine timbers, cross-ties, or cross-arms. The best results are obtained in the treatment of round timbers on which an unbroken zone of porous sapwood surrounds the more impervious heartwood. For this reason round fence posts are preferable for treatment to split posts, in which the heartwood is directly exposed. One of the chief advantages of the process lies in the fact that it can be effectively applied to parts of timbers which are especially subjected to rapid decay, such as the butts of fence posts and telephone poles, without wasting preservative on other parts.

Extensive experiments by the Forest Service with fence posts, telephone poles, and mine timbers have given satisfactory results. There is little doubt that the method is applicable to the treatment of small-dimension timbers, such as cross-arms, underground conduits, shingles, and other wood in small sizes. No difficulty should be encountered in treating cross-ties and piling of such woods as loblolly pine, black and tupelo gum, western yellow pine, and lodgepole pine. Fairly good results have been obtained in the treatment of arborvitæ,

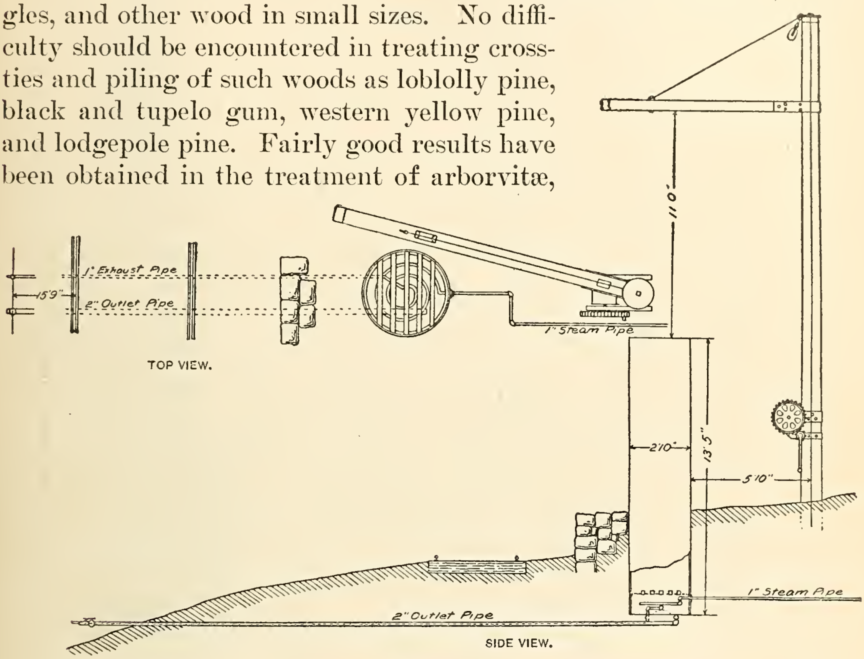

FIG. 3.—Diagram of an experimental tank used for treating mine timbers.

chestnut, and red oak, but the experiments with these woods do not yet warrant the application of the method to the treatment of piling and ties manufactured from them. The process is being rapidly developed, and it is probable that future experiments will reveal methods of applying it to many other species and purposes.

Though considerable progress has been made within the last few years in our knowledge of the ease or difficulty with which different timbers absorb the preservative under varying conditions, much yet remains to be done. It is therefore unwise at the present time to predict in detail the possibilities of the open-tank method. It is certain, however, that for many forms of timber manufactured from many

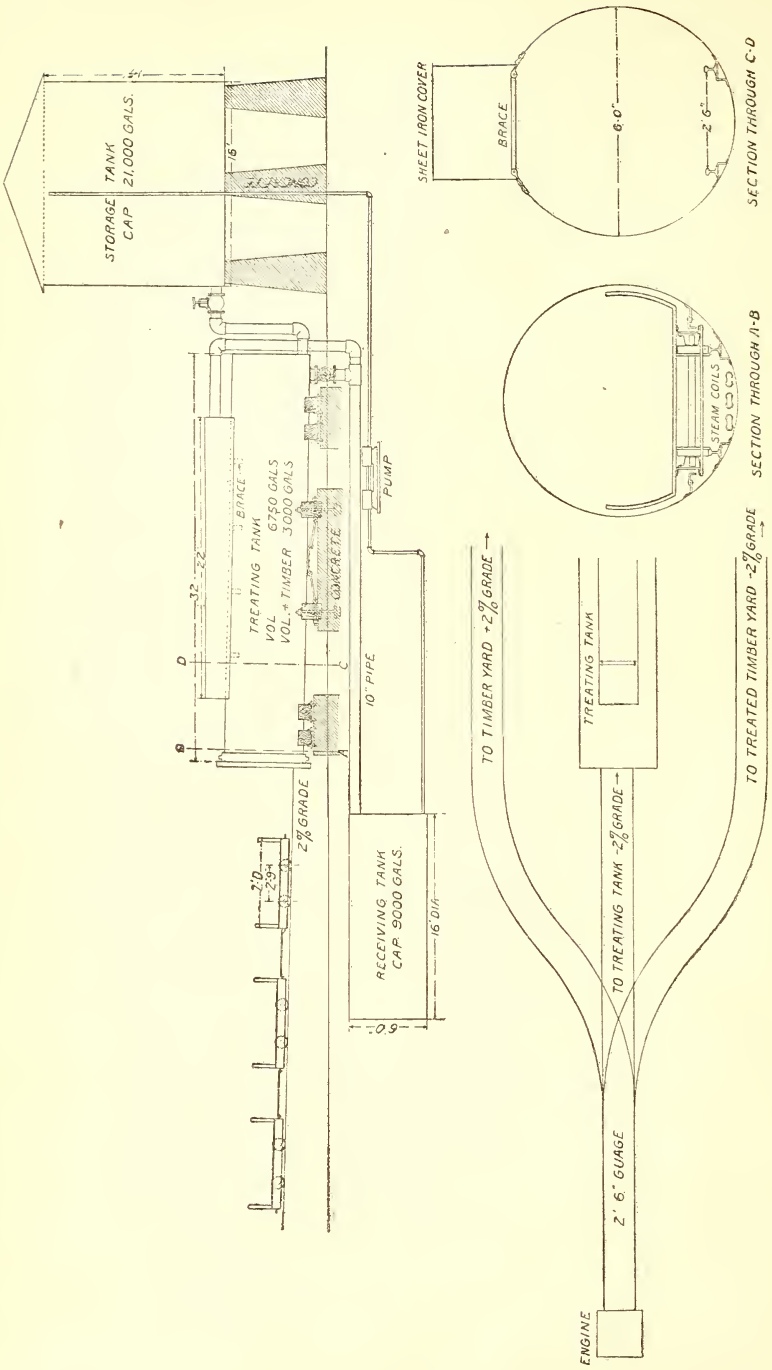

Fig. 4.—Diagram of a small commercial plant for treating mine timbers, cross-ties, cross-arms, etc.

species this method is practicable in cases where no other process could be employed, and that its general application will make possible the treatment of much larger quantities of timber in the future than in the past.

For those cases to which it is properly applicable, the saving effected by the open-tank method is readily apparent. Not only is the cost of operation and maintenance comparatively slight, but the cost of installation is probably less than one-fourth of that of a pressure-cylinder plant of the same daily capacity. Moreover, the open-tank apparatus may be moved with comparative ease, so that it may more nearly follow the base of supply, with a consequent saving of freight charges. It should be distinctly borne in mind that it is not a universal substitute for the pressure processes, and its future usefulness will largely depend upon the care and foresight which are exercised in its application.

NECESSARY APPARATUS.

The simplest type of open-tank apparatus consists of a vat to be partly filled with a preservative, in which the timber is submerged, and under which a fire can be built. An apparatus of this kind may be placed on wheels and drawn from one place to another. However, where the saving of time is essential and the treatment is conducted on a larger scale, additional apparatus is necessary for the most economical and convenient treatment. If the timbers are of such size and form that it is practicable to change them from the hot to the cold bath, two tanks are necessary, one to contain the hot preservative—preferably equipped with steam coils—and the other to contain the cold preservative. For timbers too large to be transferred during treatment, the plant should consist of a treating tank, a supply tank, and a receiving tank. This equipment will make it possible to shorten the treatment by running out the hot liquid into the receiving tank and admitting the cold liquid simultaneously. The preservative can later be pumped back into the supply tank.

In most cases a tank built from three-sixteenths or one-fourth inch iron or steel will give the best results. Where steam can be supplied at a nominal cost, steam coils are preferable for heating.

Approved:

James Wilson,

Secretary.

Washington, D. C., *April 30, 1907.*

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